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SOLAR TRICKLE SYSTEM INTEGRATED WITH WOOD HEATING

Prepared for

MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

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SOLAR TRICKLE SYSTEM INTEGRATED WITH WOOD HEATING

Prepared by

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Jaybird Ranch
Boulder, MT 59632

February, 1981

Prepared for

Montana Department of Natural Resources and Conservation
32 South Ewing, Helena, Montana 59620
Renewable Energy and Conservation Program
Grant Agreement Number 100-771

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I Objective: The project was designed as a demonstration project using sun and wood as renewable resources to provide the major portion of the heating and domestic hot water supply of a large, well insulated rural home utilizing wood-fired fireplace boilers.

a. Originally the system was to be augmented by optional wind energy to develop heat and/or electrical auxilliary supply. This portion of the grant was not funded. Connections to the heat storage tank are provided.

b. A solar greenhouse as a supplemental project was not funded. Plumbing, sewer, and electrical supply lines have been installed and double glazed windows have been purchased for this project.

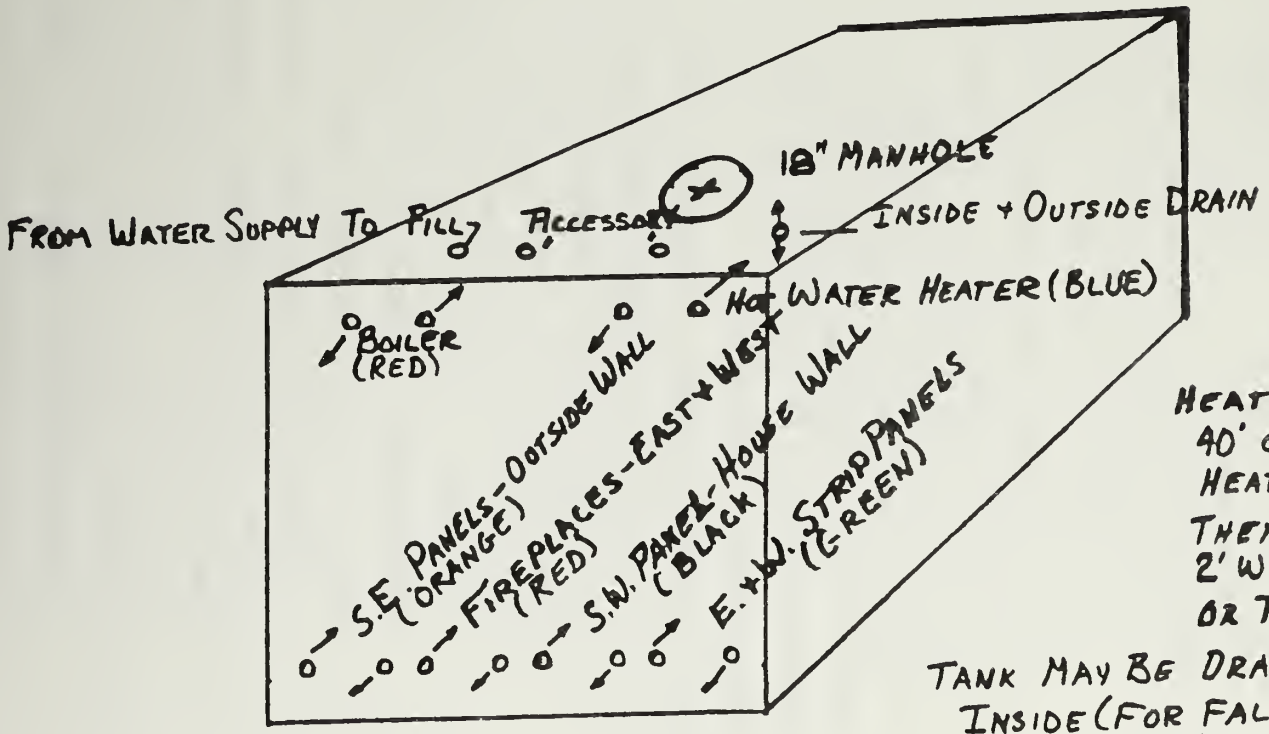
II Project Implementation (discussed a. through d.(5)): The project was completed in phases as planned. Planning was largely complete at time of the initial proposal.

a. Storage tank--installed in basement: (Fig. 1) The storage tank is a 2500 gal. septic tank, bivalved with no baffles. Heat exchangers are 40' of 1" fin tube which exchanges 960 BTU per foot--38,400 BTU each. The exchangers (4 input in the bottom, 2 output at the top) are vented through the sides using 1" pipe with a baffle or shield soldered in place and installed as the tank was constructed. The tank was cheap and was installed in situ by J & R Pre-cast of Three Forks, Mont. The walls are 4" thick (1/2" to 1" more than the usual tank).

Problem: The bivalved tank leaked at the seam when it was sealed rigidly with epoxy and with automotive body putty.

Reason: The water temperature differential cracked the rigid seam.

HEAT SINK. 2500 GAL. CONCRETE SEPTIC TANK (NO BAFFLES) - BIVALVED AND SEALED WITH SILICONE CAULK - 6'6" (W) x 5'7" (H) x 12' (L) - 4" WALLS. 1' OF FIST SIZED RIVER ROCK SURROUNDS TANK + 6" POLYURETHANE AGAINST OUTSIDE WALLS. 1" VERMICULITE UNDER ROCK - 1' FIBRE GLASS OVER ROCK. FINISH WALLS FILLED WITH 6" FOAM AROUND BLOCK WALLS - PUMICE - WHICH ARE VERMICULITE FILLED.


FROM WATER SUPPLY TO FILL
ACCESSORY
18" MANHOLE
INSIDE + OUTSIDE DRAIN
HOT WATER HEATER (BLUE)
BOILER (RED)
S.E. PANELS - OUTSIDE WALL (ORANGE)
FIREPLACES - EAST + WEST (RED)
S.W. PANEL - HOUSE WALL (BLACK)
E. + W. STRIP PANELS (GREEN)

HEAT EXCHANGERS ARE 40' OF 1" FINNED BASEBOARD HEAT TUBING - 960 BTU/FT. THEY ARE 10' LONG (4 LENGTHS) 2' WIDE + 1' FROM BOTTOM OR TOP OF TANK.

TANK MAY BE DRAINED TO OUTSIDE OR INSIDE (FOR FALLOUT SHELTER USE) WITH FOOT VALVE BOTTOM OF DRAIN LINE.

CIRCULATING PUMPS TO ALL EXCHANGERS BUT HOT WATER PREHEAT.

FIG. 1

Solution: Silicone caulk worked perfectly to seal the seam.

The tank is surrounded by fist-sized river rock obtained from a nearby placer tailings, sits on a grid of 4" x 8" timbers, in an insulated concrete block room with surrounding walnut paneling wall filled with foam (6"). The upper surface, pipes, sensors and manhole cover are covered with fibreglass roll insulation (12") and are accessible through a manhole.

Problem: Pipes from exchangers were brought out the end of the tank and then to top into the floor deck and back down to the furnace room. This was unnecessary plumbing, increasing friction for pumps and cost of installation.

Solution: Go directly through the wall of the storage tank room to furnace/control room.

We are very satisfied with the heat storage tank and controls. It is efficient and cheap if self-installed.

b. Distribution system: Installed in floor of house.

1. A hot water propane furnace was installed for the basic and/or standby heating plant. No problems have been encountered with the furnace. The cast iron jacket was tapped and threaded to receive one of the upper heat exchangers. The supply in the lower boiler jacket, return in the upper boiler jacket. A 1/12 hp Bell and Gossett circulating pump provides all the necessary circulation and runs continuously during the furnace heating season--about 6 1/2 to 7 mo/yr.

Problem: The jacket of cast iron is thin and thus easy to tap too loosely. Therefore, the male adapters were loose.

Solution: Proper tapping; do not run tab too far into jacket. Nylon pipe tape and time stopped the slight leak.

Caution: The furnace jacket should be large enough to be useful for preheating. The temperature of the jacket (pre-heat) runs from 90 to 155°. No control to shut down the pump has yet been needed.

2. Radiant heat (Fig. 2) is from copper pipe in the concrete slab floor. Four zones have been installed.

This system has been delightful. The floors are warm and physiologically comfortable with house thermostats set at 62° for each zone.

Problem: None

Comment: More efficient 3 wire thermostat furnace controls are available.

Bonus: The 8" slab floor over the storage tank, furnace room and basement room wing of the house (28' x 40') with a toilet provides an effective self-contained fallout shelter (rural setting--with a septic tank and drain field). The heat storage tank would provide water in such a circumstance and is tapped for this function.

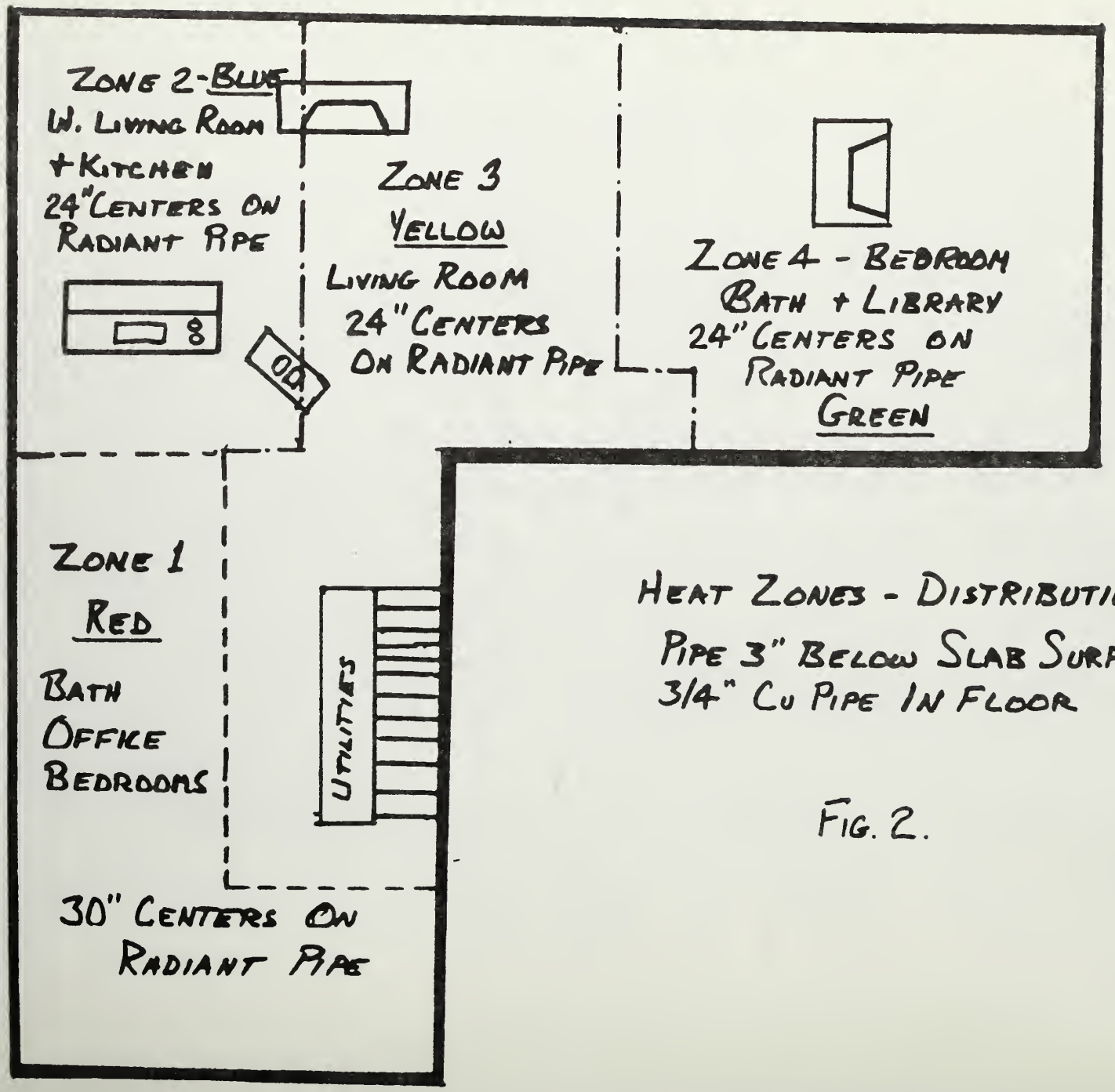
c. Domestic Hot Water System: Hot water tanks in furnace control room and distributed in floor. The domestic hot water supply enters a water softener, goes through one of the two upper heat exchangers in the heat storage tank, returns to a 150 gal. storage tank (pre-heat) in an insulated self constructed box and then goes to the water heater.

Comment: No problems. This system works beautifully. All items are standard.

d. Energy Supply: Furnace in basement. Fireplaces in living room and master bedroom.

1. The boiler is an integral part of the distribu-

tio



HEAT ZONES - DISTRIBUTION
PIPE 3" BELOW SLAB SURFACE
3/4" CU PIPE IN FLOOR

FIG. 2.

tion system. It, of course, is also a supply source and uses propane (presently the cheapest commercial energy source available for home heating in our area).

2. Fireplace boilers: These were built exactly as designed (Fig. 3). Angle irons were welded to the sides and back to increase heat exchange. The metal used was 1/4' mild steel and readily available.

   Problem: On testing the boiler, the pressure was allowed to go to 40-50# p.s.i.--much too high. One boiler expanded like a football bladder, but this exposed one weakness in design. Bolts should be welded in place--one through each side wall and two through the back.

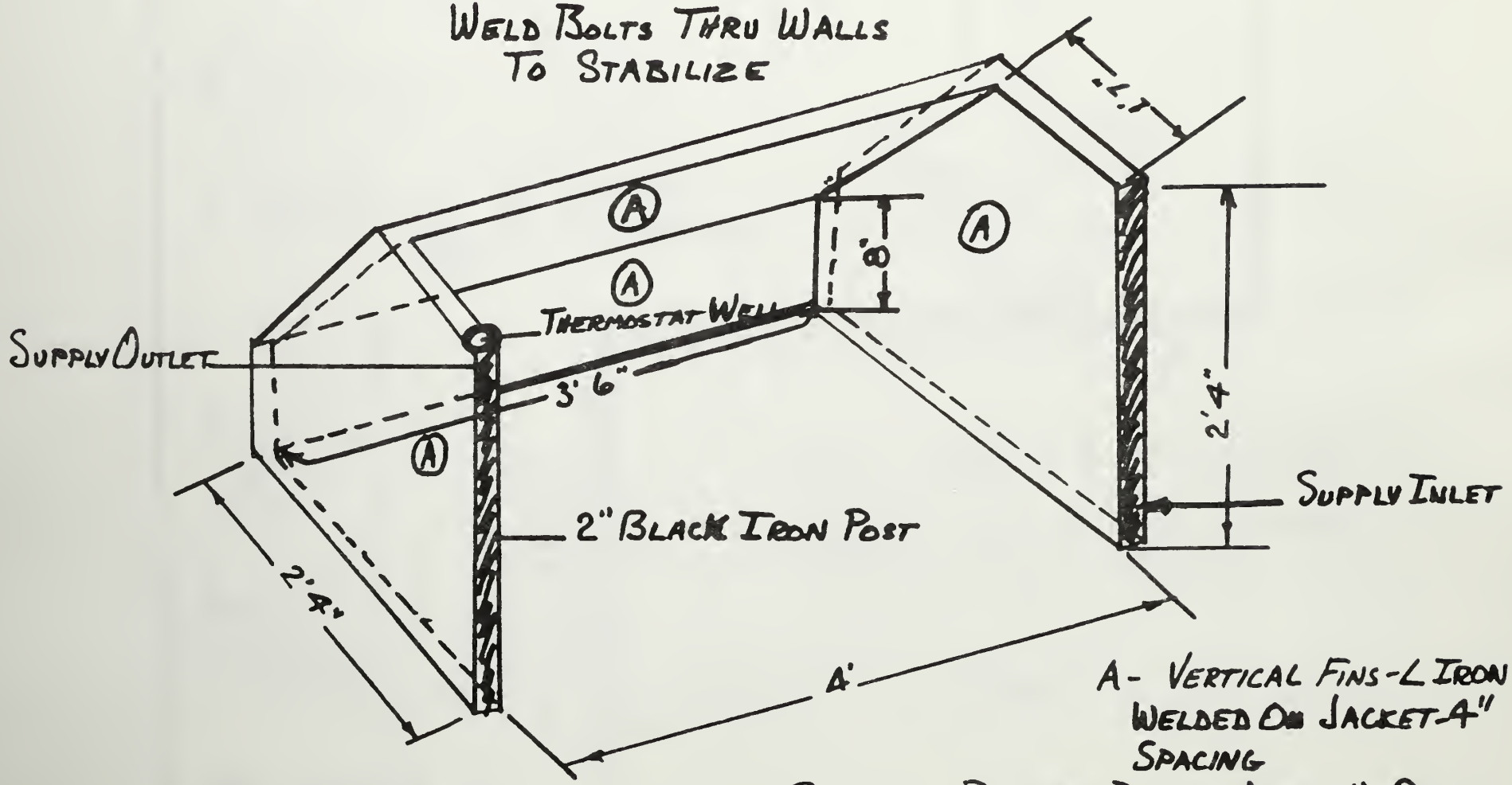
   Comment: 7/32" or 3/16" steel could be used.

3. Fireplace controls and pumps: Both fireplace boilers supply the same heat exchanger on a common line. Monoflow valves had been installed to prevent back circulation. Bell and Gossett 1/12 HP circulating pumps were used, one for each boiler. A 30# relief valve was installed for each boiler. A high-low limit thermostatic control was installed for each boiler.

   Problems: Monoflow valves did not function as planned. Circulation, at times, was backwards. The pressure relief valves were too insensitive. Steam was vented at times when temperature was too hot. The high-low limit controls supplied were not proper since they turned on at low temperatures and stayed on until the temperature dropped again.

FIREPLACE BOILER JACKETS
1/4" IRON PLATE

WELD BOLTS THRU WALLS
TO STABILIZE



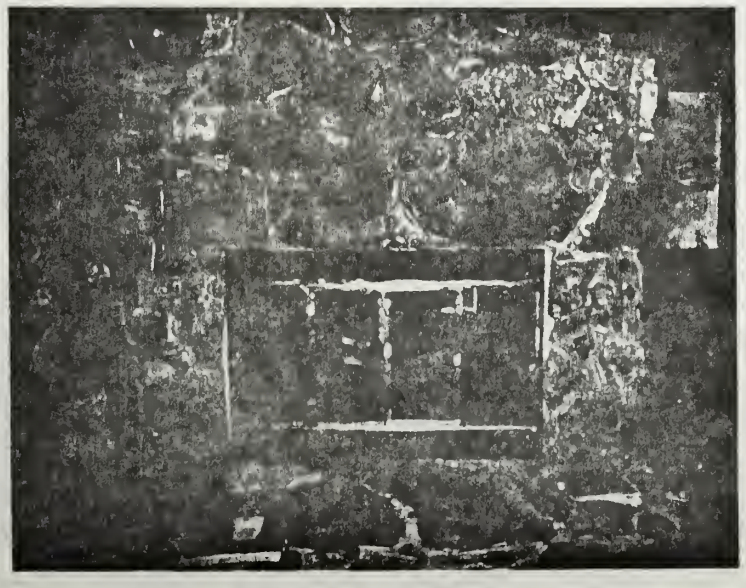
A - VERTICAL FINS - L IRON
WELDED ON JACKET 4"
SPACING

SUPPLY & RETURN PIPES ARE 2" PIPE
WELDED LEADING EDGE OF JACKET

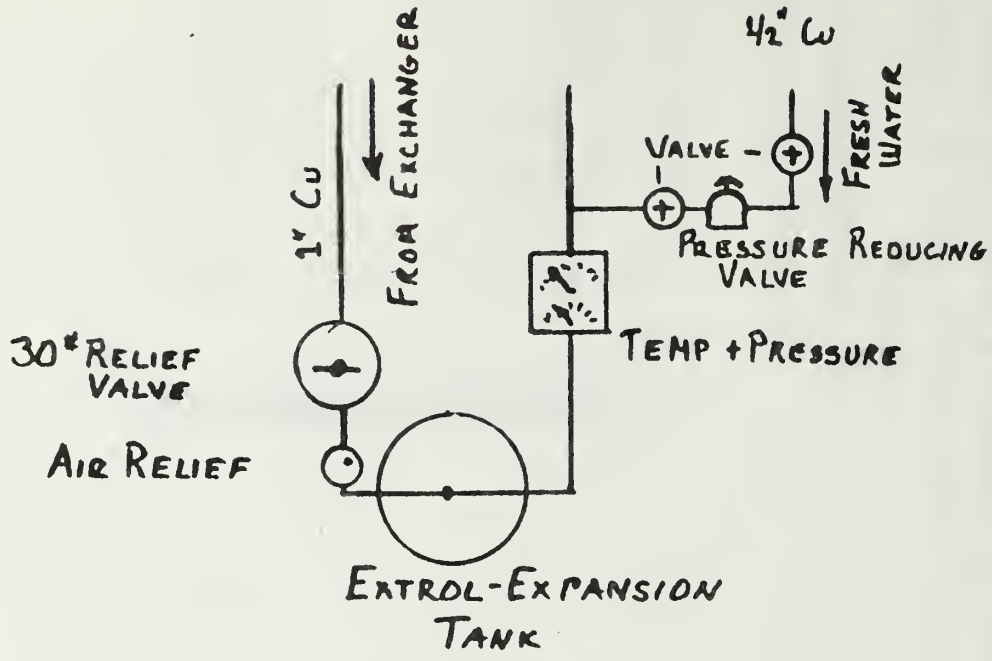
ISOMETRIC

FIG. 3.

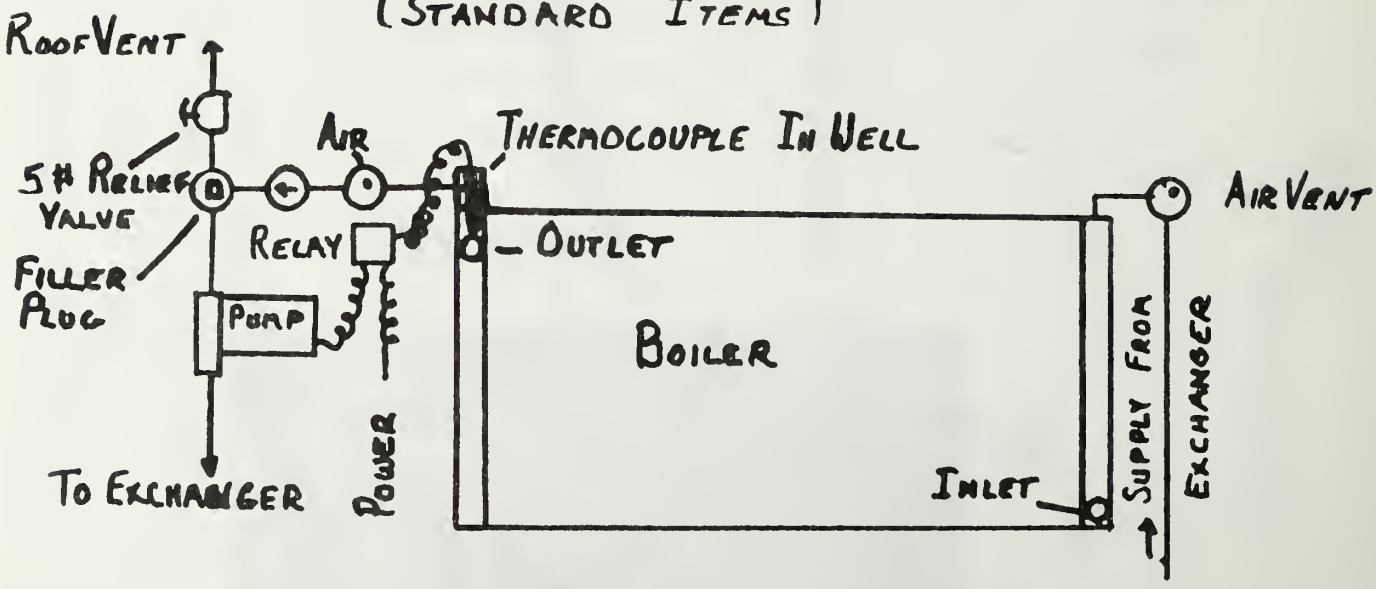
Solution: Check valves were installed in each boiler return line, as were ½" relief valves and high-low limit controls from a refrigeration air conditioning system. The new hi-low limit controls turn on pumps at 155-160° and shut them off at 110-120°. (Limit settings may be changed.) Control is manufactured by Ranco. One expansion tank is installed in line in the basement and an accessory pressure relief valve @ 30# is in basement at control panel, as well as a pressure reducer valve and a connection to the water supply to maintain water in the system. The general schematic is shown in (Fig. 4). Monoflow valves are not needed. Access to controls in each fireplace is seen in photos 1 and 2; closeup in photos 3 and 4.



1. Living room fireplace



Fireplace Safety Controls + Water Supply
(Standard Items)



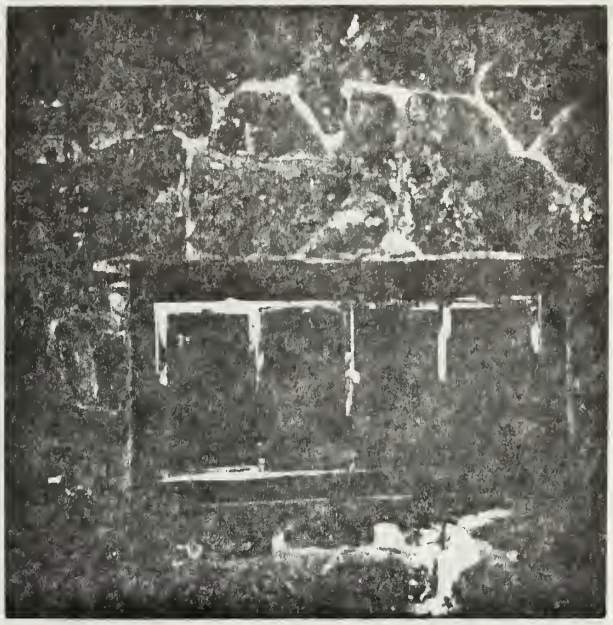
1" Cu Lines

Fireplace Schematic

1/12 HP 115v Bell + Gosset Circulating Pump
Series 100 - Standard Item

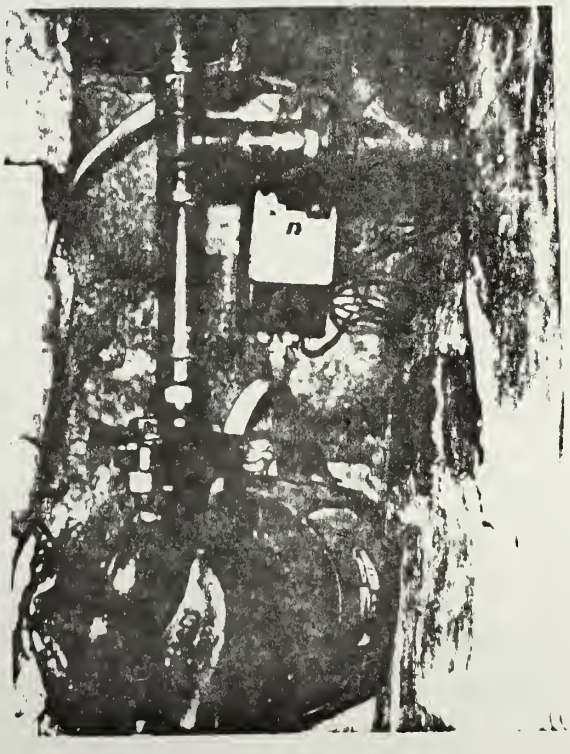
Relay Is Standard Item Refrigeration / Air Condition
Control - Turns On At 165° - Off At 120°
Boiler Tested At 30#

Fig. 4



2. Bedroom fireplace

3. Closeup, living-room fireplace



4. Closeup, bedroom fireplace

This system works beautifully, is efficient and has heated our home and provided hot water in the coldest weather--on one occasion for 3 days when we were out of propane. During this time with constant hot water usage the temperature of the storage tank slowly dropped about 10°/day.

d. Panels:

1. These were built as a trickle system, insulated, corrugated and embossed aluminum, painted with "alu prep", magnesium oxide primer and black enamel high temperature resistant paint (obtained at auto supply store). They were cured for weeks.
   Problem: The paint peels and oxidizes from the action of the heat and of the ethylene glycol (Prestone).
   Solution: Use corrugated aluminum already painted. Since black is not available, I would buy a dark color (e.g. red) and paint it black.
2. The wood of the panels is redwood. Glass is double glazed, low lead PPG; patiodoor sizes were used because of low prices.
   Problem: The material glazing the glass sheets together melted and the metal strip separating the glass sagged. Vents to prevent excess heat and outgassing were inadequate.
   Solution: Replacement of three panels and repair of two. Installation of aluminum strips over the edge of the panels to absorb heat and dissipate it.
3. The panel pumps have frequently air locked and originally the 1/12 HP pumps recommended

the master plumber were inadequate to pump to pump against a 12' head on a 100' line. A number of different pumps and control panel designs has been used. The most recent design uses Bell and Gossett, Series 60 1/4 HP pumps. Design as in (Fig. 5). Photo 5.

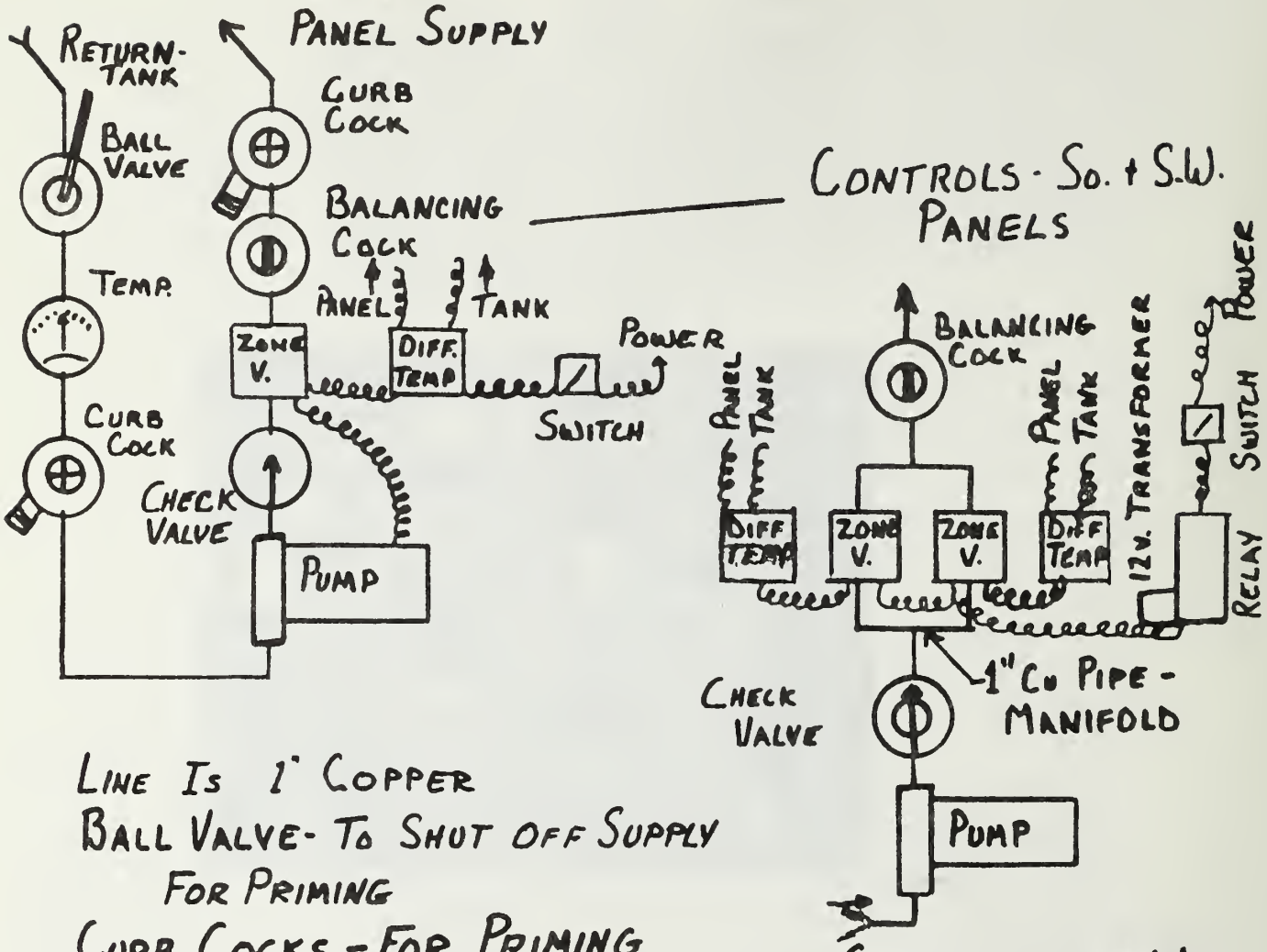
5. Pumps and control panel

Comment: I would <u>not</u> use a trickle system in another installation but use coiled thin walled copper pipe as heat collectors within the panels in a closed system. We are on the verge of making this modification now.

4. The collection gutters at the bottom of the panels are of aluminum and in 8' sections fabricated by a sheet metal shop. As the water left the manifolds (1/8" holes on 4-5' of 1/2" copper pipe controlled by balancing cocks) it tended to curl frontally on the pipes and drop outside of the gutters.

   Solution: An aluminum strip folded about the manifold forces the stream to drop on the

Schematic Panel Controls



Line Is 1" Copper

Ball Valve - To Shut Off Supply For Priming

Curb Cocks - For Priming

Balancing Cock - Optional If One Pump + Manifold Used

Zone Valve - Optional With One Pump + Manifold

Differential Temperature Control - DeltaT - Mod. DTT 80 Heliotrope General, 3733 Kenora Drive, Spring Valley, California, 92077

Check Valve - Necessary To Maintain Pump Prime Another Check Necessary At Panel Trough

Pump - Series 60 1/4 H.P. 4.9 Amps 115 V. 1725 RPM Bell + Gosset. 8200 N. Austin Ave., Morton Grove, Illinois.

Fig. 5.

panel as the pump shuts on and off.

5. Condensation (a distallate of the water) on the glass within the panel concentrates the solution causing the ethylene glycol to get jelly-like and the volume to decrease and then the system sucks air (out of the troughs) and thus air-locks the pumps.

   Solution: Add solution/water or utilize fluid that won't vaporize, e.g. thin oil.

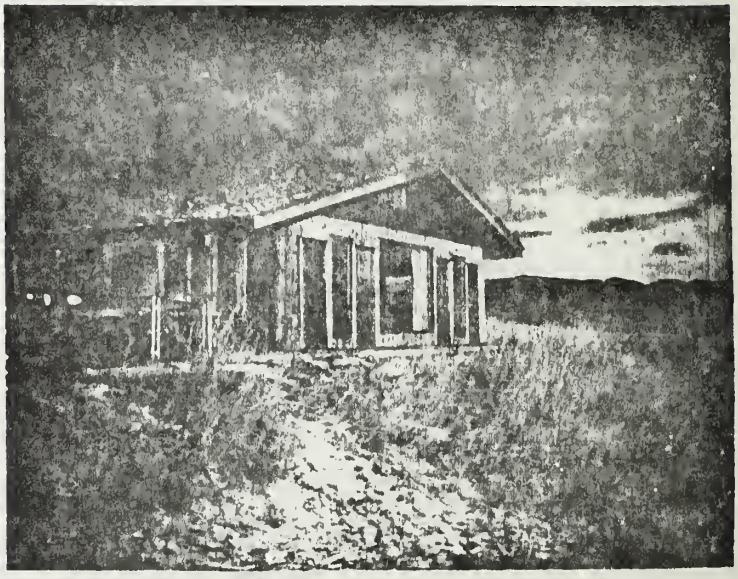
   Comment: A closed system, obviously, would stop this. This problem remains our biggest problem. It requires 30 gal. of ethylene glycol and 30 gal. of water to charge the entire system.

   When the panels are working, any one of the 3 systems heats the storage tank to 120° in one day. If all three are working, they will provide enough BTU's for at least 30% of the house heat and certainly all of the water supply. The panels are about 27% of the floor space and should, if working, provide about 30% of the heat.

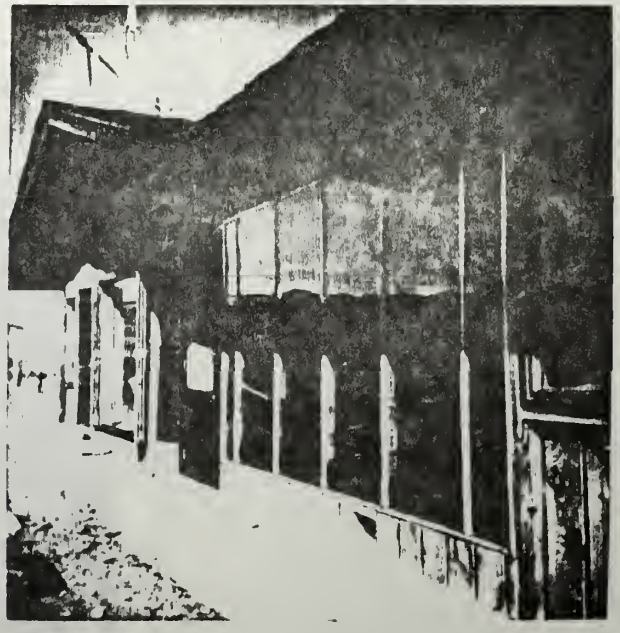
   So far, I consider the trickle system panels difficult to manage, but am still modifying them. Panels shown, photos 6, 7, 8, 9.

6. Southfacing panels

7. South facing panels



8. East facing panels



9. West facing panels

1. Project Planning and Equipment Acquisition:

Information utilized in designing the collector system, storage tank and controls was obtained from available literature found in book stores, libraries, etc. Most of the units, e.g. collectors and boilers, were self designed. Major equipment was supplied by:

a. Storage tank. J & R Pre Cast, Three Forks, Mont.
b. Circulating pumps. 3 1/12 HP Bell & Gossett pumps for boilers and exchanger to furnace; valves and fittings by Pallister Plg. & Htg., 1310 Boulder, Helena, Mt. 59601.
c. Collector glass. Pittsburgh Plate Glass, 840 Utah Ave., Butte, Mt. 59701.
d. Differential collector controls. Delta T, Mod DTT-80 Heliotrope General, 3733 Kenora Dr., Spring Valley, California 92077.
e. Controls for fireplaces. Pallister Plg. & Htg., 1310 Boulder Ave., Helena, Mt. 59601.

The three pumps used for collectors required a shipping time of about two to three months. Collector glass that was fabricated took about two months (using standard [illegible] patio door glass oviated this). Fireplace controls were fabricated to order--about two months. Aluminum collector panels were purchased at Sears and painted with high temperature black automotive paint over zinc chromate undercoat.

2. System Installation:

It took about two weeks to fabricate the fireplace boilers by part time welding. Component parts of the boilers were cut by Caird Engineering, Boulder Ave., Helena, Montana. The fireplaces were constructed after the boilers (which are removable) were in place. The control system and valves were modified six times (final schematic Fig. 4). Collectors were self-fabricated. They are backed by 6" of insulation (fibreglass) in areas where they do not directly rest on the insulated house wall. Embossed aluminum ribbed paneling of standard length was ordered from

Sears Roebuck and were cured several weeks after painting. Redwood frames fabricated from 2 x 4's were used for glazing. Windows were caulked with silicone cpd and aluminum strips have been partially installed over the edges to dissipate heat that has melted some of the window sealant that binds the two sheets of glass together. The gutters to collect the fluids were fabricated by Helena Sheet Metal, joined by snap rivets and sealed by silicone. Collecting pipes were joined to the troughs using brass basin drains and sealed by silicone. A spring loaded check valve and a 45° elbow are interposed between the check valve to the bottom of the trough. The "trickle" was devised by using 1/2" cu pipe with one 1/8" holes at each edge of the "ribs" of the aluminum backing. This perforated pipe is in lengths of about 5' each with a balancing cock in the middle of this pipe. The glass is by Pittsburgh Plate Glass, Butte, Mt., low lead and mostly of standard sizes which cost about 25% less than special sizes.

Intermittent construction and modification of the collectors has occurred over two years. With materials on hand, they could be built in two to three weeks by one person.

3. System Testing and Modification:

No especial testing of the systems was devised. All modifications so far have been successful but for the collector panels themselves. Modification in collector controls and pumps have been successful. Fireplace boiler and controls are seen in (Fig. 4) and photos 2 and 3. Collector and fireplace safety controls and exchangers to furnace boiler and hot water tank are shown in (Fig. 5) and photo 5.

4. System performance. Monitoring of the system has not been done by strict scientific modalities. In our original grant application we had hoped for monitoring by Charless Fowlkes who was offering such a service at that time, but which was not funded.

The fireplace boilers, if both are operating, will deliver hot water to the storage tank at 155° dropping to 120°. The

tank temperature delivers water to the propane furnace jacket at 135° when the fireplaces are fired.

The south facing panels deliver water to the storage tank, that, upon leaving the tank for recycling still is at 120°. This stored heat is utilized in preheating the domestic hot water tank and the furnace boiler.

The collecting system has not operated a sufficient length of time to give reasonable figures on efficiency or dollar savings.

5. System cost: Represents 34% of labor expended on house through 15 Feb 77, as outlined in grant proposal and is estimated on basis of materials used for all renewable energy projects. It includes house insulation, concrete slab, double studded and sheeted walls, double glazed windows and heavy doors.

Schedules

*Wages	15,300.80
Soc. Sec. & Work. Comp.	718.85

Schedules expended thru 15 Feb 77 (from project proposal) and thru 31 Dec 77

*Senior Plumbing and Heating--Panels, to date 1" type M copper, 80.64; 1/2" Bal cocks, 74.36; 3/4" vent L's, 19.25; air vents, 51.00; 1" pipe fittings, 148.19.	373.74
Tank: 267' slant fin tubing, 1,044.75; fittings, 61.15	1,105.90
Control room: 3-1" sweat valves; 25-90° L's; 1 temp guage fitting adaptors; 25-1" copper straps; 5- B&G pumps; 1-3" coupling; 1-plug; 12-air vents; 20-1" copper L's, strap iron; 11-1 1/4" nipples; 7-3/4"x1/8" bushing; 10-vent L's; pipe dope; 1/2" copper check valve	520.49
Expansion tank-19"x16": pressure gauge, check valve 1/2x1/4 1" strap; 40-1/2 black T's	62.11
1 1/2" 90°; 2" T; 1 1/2" 45°; 2" straight 45° 1 1/2" coupling; 2" cpling	25.92
2"x1" 90°; 1 1/4"x1" 90°; hanger iron; Teflon seal; 1x6" nipple; 1x8" nipple; 1" locknut; Gerber ball cock, vacuum breaker; 2x1" Bell reducer	34.71

Brass 3/4:x1/2" bushings 2.88

Transformers-24 volt; float vents; 2 B&G pumps; 1" gate valve; 3/4" zone valves; 3/4"x1" bal cocks; 3/4" T&P valve; 3/4" float cock, 500# mini-trol; solder; flux; rfg brush 397.46

Galv. pressure tank, 168.35; 30# extrol; 2" blk caps; 2"x1" Bell Red 195.02

Boiler & fittings (asst) 779.28

*Senior Plumbing & Heating--Distribution & Collection System

1" valve, 1" adapter, 3/4" watts; 1 1/4" air purger; 1" check valve--39.88; 12 air vents, 20 1" 90's, Rigid Rute--65.25; 25-1" Cu 90's, 2 Honeywell controls & temp & pressure gauge--50.67; 25-1"xplg, 25- 3/4" 90° vents, 12 air vents, 3/4"x 1/8" galv bushing, 1/2" Nibco, 1x1/8"x1" baseboard T, 1" nipple, 1# seal--117.84; 3/4" cap, 1" cap, 1 1/r"x1" red, 1"x3/4" red, 1 1/2"x3/4" T, k/2" c&c stop--26.63; 6" Crete sleeve, 4" Crete sleeve, 3/4" meter valve 3/4- 3 part cplg--43.43; thermostats--29.20; 1" T, 1"x3/4" T, k:x3/4"x3/4" T, 1"cplgs, gate valves 1"x3/4", 1/2"x3/4" stop & waste, 3/4" silcocks, 1"x3/4" T, 1"x1/2" T, 1/2" pressure relief valves--149.15; 3/4" M Hand (2000'), 1: M Hand (500'), 1 1/4" M Hand (120'), 3/4" 1-soft-60°, 1 1/4"x3/4" T, 1 1/4 cap, 1 1/4 90°, 1" 90°, 1" 45°, baseboard T's, 1"x3.4" Red L's, 1" male adapters--1,406.99; 3 aquastat, 1" blk T/c, 3/4" blk T/c, 2 blk T/c--137.67; 1x3/4" T, 1/4"x3/4" T, 1 1/4" T--16.87; Bush--1.02 2,084.10

*Pacific Hardware--Solar

6"x6"x6" mat-76.00; fireplace rebar,48.88; 10" A1 Bands,9.36; Cu L's tank,10.32; foot valve & ejectors-tank,27.75; rebar-2500'-tank room & floor,381.80; tie wire #9 & 12 1/2,128.79; rebar for 8" deck,250.00; pressure gauge-foot valves,26.72; rebar 2520'-distribution slab,118.44; Cu fittings,13.08; form nails, 10.40; rebar 1400',65.80; 2 rolls #9 tire wire,32.40; rebar 380', 13.63 1,213.37

Insulation:
Tank Room--vermiculite, Peterson Lumber,255.72; vermiculite & styrofoam, Linderkind, 153.25; foam, Pence Bailly, 255# 6" @.55, 140.00 538.97

Excavating and blasting:
Blasting-tank & control room, 275.00; excavation and backfill-tank & control room, 482.50; load & haul rocks to tank room,132.00; backfill to tank room,110.00; fireplace footings,228.00; backfill & grading-retaining wall solar panels,220.00 1,219.50

*Speck Ready Mix Concrete, Whitehall--Concrete:
2 1/2 yds footings-tank room,88.75; 11 yds-basement footings (60% applicable to tank & control room & south solar wall),219.30; basement floor-13 1/2 yds(11% applicable for control room),47.00; footing walls for 28x70 distribution slab-26 yds(50% applicable),411.90; fireplace footings-8yds,271.60; 28'x70' heat slab-28 1/4 yds(50% applicable),447.05; steps & retaining walls-7 yds(50% applicable),213.50; solar retaining wall, 244.00 2,400.70

*Linderkind, Basement - 60%:
Snap ties, wedges,44.94; lime, nails, cement, shims,97.48; asphalt-tank,7.11; distribution-slabs(50%), walls: Visqueen,13.68; snap ties, 12.12; nails, 152.62 327.95

*Boulder Lumber:
Coupler, adapters,-tank room,1.63; Walls 50%-lumber--double studs, headers, plates & trimmers, double 5/8" ply sheeting,391.70; 2x6 headers, plates,127.13; 2/4, 2.6, 2x8, 2x10, 2x12 headers, trimmer plates,346.76; 5/8" ext. ply walls & ceiling double sheeted,676.33; insulation-outside walls, windows, doors (50%), 27.18 1,572.20

*Cloke:
Bell wire-heat control,10.00; breakers(controls), 6.98; fuse adapters,3.12; #6 bare wire,12.50; boxes-switches in control room,26.28; switches and fuses-control,14.37; plates-control room, 1.98; breakers-controls,21.91 139.14

*Hawk Electric:
Heat distribution,168.15 168.15

*Caird:
Fireplace waterjackets,451.59; welding rod,16.45 468.04

*J&R Precast:
Heat storage tank-2500 gal, lid & riser,610.00 610.00

*Helena Sheet Metal:
Collars-trim,12.54 — 12.54

*American Sheet Metal:
Stack, pipe, collar roof jack, roof jack — 89.76

*Lindsay Well Drilling:
250# #6 wire (50%) Aux power & pump,60.00 — 60.00

*Carl Weismanner
Hinge-control room,1.24 — 1.24

*Osco's:
Prestone II to charge panels & heat system-
100 gal @3.39; paint 10 cans,19.90 — 358.90

*Kruses:
Redwood-solar panels,263.50; studs, plates (50%), — 1,159.03

*Sears:
Solar panel AL sheets & return pipes — 419.53

*Masonry Materials: Kanta Products
Fireplace liner,79.00; basement blocks, flat
60% solar,532.62 — 611.62

*Gambles:
Control room: nuts, ferrule, valve, paint (code),
fuses, plugs, L's, Street L brass, nipples 3/4"
flare fittings,39.52 — 39.52

*Brand S Lumber:
Plates, headers, trimmers & form lumber (50%) — 68.30

*Allen Electric:
Emergency-standby outlets,40.00; Sierra plates,6.60 — 46.60

*B. L. Cooper:
Trimmers, headers, plates & form lumber (50% solar),
173.96; form lumber,82.10; form lumber,27.70; form
lumber-tank room(100% solar),151.40 — 435.16

*Parts Supply:
Paint for panels,142.20 — 142.20

*Travel:
Travel to Helena & drayage: Franchi's, gasoline 1500.00
34% to project,510.00; consult with Huckaba in Cooke
City,30.38; telephone-34% to project(total 680.31),
231.30 — 771.68

TOTAL thru 31 Dec 77 — 31, 497.81

1978 Schedules

*Edmund Scientific:	5.00
Helena Sand & Gravel: fireplace sand	6.75
Linder-Kind: lime for fireplaces	60.50
Boulder Lumber: cement & lime	37.62
Thurman: panels	42.14
Power Townsend:	4.30
Carson: aluminum troughs	375.65
Home Center:	3.30
Natl. Temp. Control: fireplace	55.29
City Plumbing: basin drains	39.80
PPG: panel glass	2, 963.82
Pacific Hdw.: steel for fireplace	60.85
Caird: welding rod for fireplace	26.52
Boulder Lumber: lumber for panels, insulation	454.47
Radio Shack:	5.99
Columbia Paint:	6.90
Heliotrope General: DTT controls	266.00
B. L. Cooper: lumber for panels	13.32
Speck: fireplace sand	45.00
Gilmer: fill and grading for panel sidewalks	550.00
Pacific Hdw: 1" sq. rod for grate	97.20
Pallister Plg. & Htg.: fittings	108.45
Smitty's:	2.25
Sears: aluminum panels	109.94
Total	5, 341.97

1979 Schedules

Pallister Plg. & Htg.: fittings	78.38
Skee's: fireplace doors	621.70
Linder-King: redwood, lime, cement	225.95
Boulder Lumber: lime, cement	36.48
UPS: redwood	184.71
Osco: prestone	294.70
Earth Supply:	5.15
Kruse: lumber	51.45
[illegible]ply: glass separators	40.20
Gambles: miscellaneous	26.45
BX & Greyhound: freight	16.83
Total	1, 612.00

1980 Schedules

Pallister Plg. & Htg. (wholesale supplier-Amfac & N.W.Paramount)		
3 B&G Pumps Mod #	@258.29 --panel control wall	774.87
B&G pump gaskets-control wall		1.35
Fittings-control wall		178.10
Valves, hose bibs, check & ball-control wall		89.46
Silicone-panel		277.21
Osco: prestone for panel		108.00
Power Townsend: self-tapping screws-panel molding		10.78
N.W. Paramount: check valves for trough-panel		37.14
Rocky Mt. Glass: glazing tape-panel		24.00
[illegible]: broken glass nontempered		18.60
[illegible] Builder: sidewall forms-panel		15.00
[illegible]: aluminum molding-panels, balance		546.19
Less--credit return, Pallister Plg. & Htg., solar		324.18
" " " " " , distribution-fittings & pipes		332.50
	Total	1, 424.02

1981 Schedules

Speck: concrete (on acct.)- reflecting sidewalk		100.00
Josh Pallister: custom labor-concrete work		416.00
Pallister Plg. & Htg.: 2" & 1 1/2" screws-panels		60.00
	Total	576.00

6. The solar panels have been functioning only for about 60 days and intermittently during that time so performance data are not yet available.

Cost breakdown:

Wages, Social Security, Work. Comp.	$16019.65
Fireplaces	2679.55
Tank and tank room	4781.35
Double wall-studding, sheeting, insulation	2808.26
Auxillary power and pump	106.60
Travel and drayage	788.51
Reflecting sidewalks	1066.00
Domestic hot water preheat system	195.02
Panels	8046.71
Control room	2133.91
Furnace	1401.78
Distribution and collection construction and prestone, conventional	4586.26
Total	$44623.00

III. Conclusions and Recommendations.

a. The fireplace boilers have been most gratifying. The present controls operate the system very efficiently and I would not change these. Boilers could be more cheaply constructed of 3/16" or 7/64" steel rather than using 1/4" and should have had strengthening bolts welded through the walls--two in back and one in each side. All of the stored hot water heat from these boilers is a surplus from usual fireplace operations.

b. The tank works very well and was cheap to install. More compact and greater BTU exchangers could have been more cheaply obtained by purchasing used refrigeration radiators frequently available at junk yards.

c. Panels: Unless cheaper and more efficient panels may be constructed or fabricated, a trickle system is not our recommendation.

1) Butyl rather than silicone caulk should have been used.

2) Aluminum molding could have been purchased more cheaply than fabricating it.

3) If the glass had set inside of the troughs at the bottom,

condensation would not dry up the system. A different heating solution (e.g. a thin oil) may yet solve this problem. Using water alone, the panels will provide all of the domestic hot water during the summer when the fireplaces are not in use. At present this area of the system requires more development.

IV. Monitoring. The only method we have of estimating efficiency is by the effect on heating bills. This information will continue to be available.

V. Public availability. All requests to view the system have been met. Two high school classes from Whitehall, 38 miles

from Boulder, have visited. Otherwise, a very few individuals have visited--perhaps an average of one per month, two from Great Falls, several from Helena or Butte and local individuals.

Visitors are welcome when we are home (appoints are best).

Response has not been estimated. Some have been enthusiastic, most non-committal. The fireplace system is very well received.

IV. Program evaluation.

We have had no problems dealing with the department.

A bulletin sent regularly to grantees describing or listing types of systems under design or completed to facilitate exchange of information and perhaps listing problems and solutions, such as the publication received recently, but in a brief form and not a "slick" would seem useful.

15 copies of this public document were published at an estimated cost of $3.50 per copy, for a total cost of $52.50, which includes $52.50 for printing and $.00 for distribution.